Economic Case Studies of Cider Apple Orchards in New York State

Gregory Peck and Whitney Knickerbocker
Horticulture Section, School of Integrative Plant Science, Cornell University, Ithaca, NY

Keywords: cost of production, enterprise budget, hard cider, net present value, orchard economics

> **"We developed economic case studies for six orchard operations located in New York State that describe the costs and returns involved in producing cider apples. Ultimately, data gathered from the six New York farms found that growing cider apples can be profitable under a number of different operational models, horticultural practices, and climates."**

In the United States (U.S.), fermented apple juice is sometimes referred to as "hard cider" and may legally contain up to 8.5% alcohol by volume. The volume of hard cider sold in the U.S. has increased nearly ten-fold over the last decade, from 5 million gallons in 2005 to 46 million gallons in 2016 (TTB 2017). In 2017, hard cider was estimated to be a US $1.3B industry supporting 820 producers across the U.S. (Brager and Crompton 2017; Brown 2018). While the national production growth rate has reportedly slowed since 2016, industry revenue is still increasing and is projected to grow at an annual average rate of at least 1.2% through 2021 (Petrillo 2016). Additionally, small- and medium-scale hard cider producers are continuing to open and/or expand production. In New York, the majority of hard cider producers are small- to medium-scale and began production within the last five years (Brown 2018; Pashow 2018). New York is also home to nationally established brands such as Angry Orchard (Boston Beer Company), which operates a research and development facility in Walden, and Johnny Appleseed (Anheuser-Busch InBev), which is reportedly made in Baldwinsville (Cazentre 2014).

The U.S. is the second largest producer of apples in the world and New York is the second largest apple producing state in the U.S. With more than 40,000 acres, New York produced 1.2 billion pounds of apples on 1,365 farms in 2016 with an annual farm gate value of over US $315M (USDA-NASS 2017). Despite NY having a successful apple industry, our recent survey work has found that there are fewer than 200 acres of specialized (those containing a high tannin concentration) or heirloom dual-purpose hard cider cultivars in the state (Pashow 2018). Most of these orchards are part of vertically integrated operations and only a small quantity of cider apples are being sold in the marketplace. A shortage of hard cider apples has created supply chain imbalances, which leads many producers to purchase culinary apples and/or import apple juice concentrate.

The rapidly expanding hard cider industry creates an opportunity for New York apple growers to supply specialty hard cider apples on a regional and, potentially, national basis. New York State is home to more cider producers than any other state in the country, and growers have started to plant new orchards to supply apples to this emerging industry (Brown 2018; Pashow 2018). New York's 93 hard cider producers account for 11% of the total number of producers in the U.S, more than in any other state. Since 2015, New York producers have made approximately 5M gallons of hard cider per year (TTB 2017). If produced from fresh fruit, this volume would require approximately 70M pounds of apples, which equates to 6% of the state's annual apple harvest. Our data shows that hard cider producers are willing to pay, on average, $0.35 per pound for these specialty apples, a significant premium over other processing markets that pay closer to $0.15 per pound (Pashow 2018).

Over the past year, we conducted a series of case studies in New York to assess the feasibility of growing hard cider apples in the state. Our goal was to compare and contrast how different approaches to producing cider apples affected the economics of the system. The six operations we studied included two in the Finger Lakes region, two along the shore of Lake Ontario, and two in the Hudson River Valley.

Materials and Methods

Between November 2017 and June 2018, we interviewed cider apple producers in three apple producing regions within New York. We purposely chose operations that were using different production practices, marketing strategies, and were from different geographic regions. Data was gathered through in-person interviews and follow-up emails with the farm owners and, in some cases, their financial officers. Case study participants were first asked to describe their farm operation in terms of its age, key sales markets, and current planting schemes. They were then asked specific questions related to the costs of 1) land preparation and planting, 2) trellis system, 3) irrigation system, 4) pest management program, 5) labor usage, 6) machine and other equipment usage, 7) animal control program, 8) their expected yields and returns for cider apples, and 9) other miscellaneous costs. Within each category, questions were designed to understand the inputs of each, both physically and economically, and to better understand what management choices would differentiate the operations from each other. The case studies were based on an amalgamation of all cider apple cultivars that the orchard owners produce on their farm. When available, we used actual data provided to us. For most operations, this included establishment costs and annual operating costs for one to five years. Potential returns and yields for mature orchards were estimated by the owners. The owners reviewed the tabulated data and were given the opportunity to make corrections.

Enterprise budgets for each case study were developed using a spreadsheet template created in Microsoft® Excel® by Farris et al. (2013). While each operation had unique costs and returns, we kept other assumptions, such as the discount rate (12%) and operational life (25 years) constant. The enterprise budgets do not account for taxes, land value, water, equipment purchases, or facility costs, as these vary greatly within and among the state's regions. A few edits were made to the Farris et al. (2013) template enterprise budgets to further track costs associated with production. These included separating the labor costs into categories of major expenses, such as harvesting and pruning labor, and creating maintenance costs for structural assets in the orchard, such as the irrigation and trellis systems. Additionally, the enterprise budgets adjust the variable costs of production. Farris et al. (2013) calculated that fixed costs were, on average, 20% of the variable costs incurred by the growers they interviewed. Therefore, the fixed costs are calculated as 20% of the total variable costs that were incurred over the lifespan of the orchard and are charged on an annual basis. Costs associated with transporting and storing apples and producing cider are not part of the case study budgets.

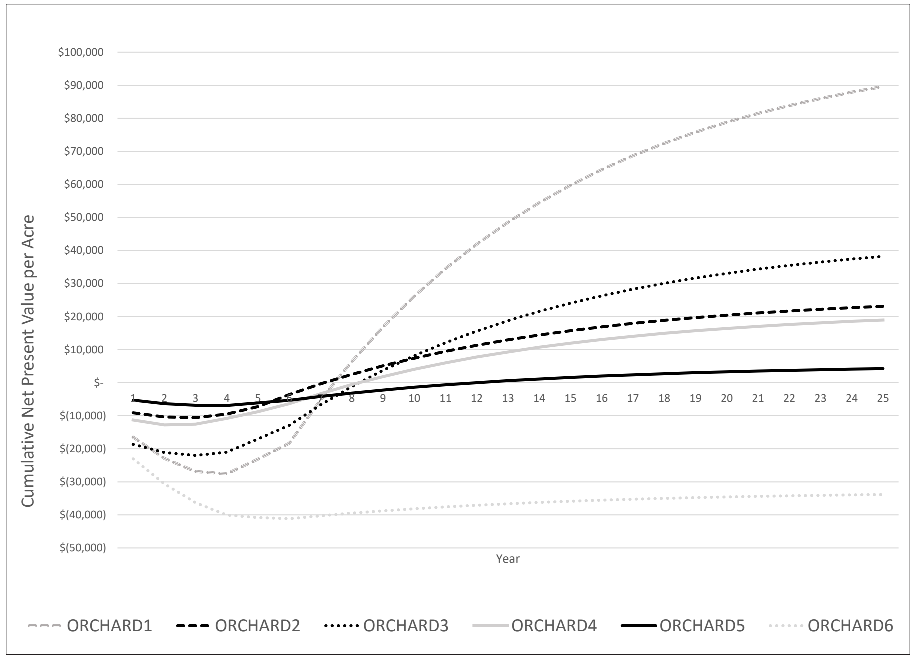

Figure 1. Twenty five-year net present value of net income before taxes for six case study orchards in New York State. Each year was calculated separately using the estimated annual profit or loss expected after subtracting the annual variable and fixed expenses.

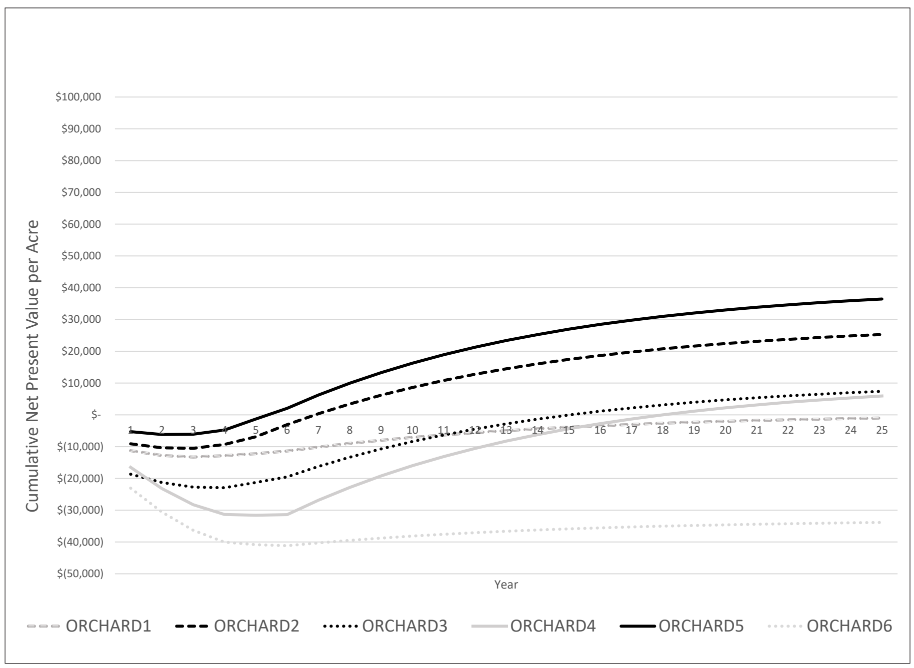

Figure 2. Twenty five-year net present value of net income before taxes for six case study orchards in New York State using an average return of $0.35 per pound for cider apples. Each year was calculated separately using the estimated annual profit or loss expected after subtracting the annual variable and fixed expenses.

Results and Discussion

The operations we studied use a range of different orchard designs, management practices, and pest control strategies, but, as calculated by the 25-year enterprise budget, five of the six operations would achieve profitability (Figure 1). We found that the five operations that broke even within 25 years, did so between seven and nineteen years, and after 25 years, the net present value of these ranged from $4,245 to $89,600 per acre (Table 1). The ORCHARD1 operation was the most profitable operation and the ORCHARD6 operation was the least profitable. There was a $123,450 difference in the 25-year cumulative net present value between these two operations.

High-density (1,000 trees per acre) culinary apple orchards in New York are estimated to have a 20-year net present value of over $32,500 per acre when prices are $0.24 per pound (Robinson et al. 2013). The ORCHARD1 and ORCHARD3 operations would likely meet or exceed this estimation, but the others would likely have been less profitable growing cider apples than culinary apples (Figure 1). Thus, cider apple growers should be aware that there are opportunity costs associated with investing in a crop with highly variable profitability.

At full production, the case study operations projected maximum yields between 16,600 and 52,600 pounds per acre. High input costs and relatively low yield (32,000 pounds per acre) for the planted tree density (1,117 trees per acre) had the greatest impact on the economics of the ORCHARD6 operation, which never achieved profitability (Figure 2). The ORCHARD6 owner did not have very much information or experience with the bearing habit and other horticultural traits of cider apples, as these trees were recently planted, and purposely decided to be conservative with their yield estimates. Culinary apple cultivars planted at a similar density to the ORCHARD6 operation (1,000 trees per acre) can achieve yields of up to 63,000 pounds per acre, and average annual yields of 42,000 pounds per acre over the long term would not be unreasonable (Robinson et al. 2013). In the

Table 1. Comparisons of key features of six hard cider apple operations in New York State.

	ORCHARD 1	ORCHARD 2	ORCHARD 3	ORCHARD 4	ORCHARD 5	ORCHARD 6
About	Small-scale intensely managed orchard in succession phase of business	Large-scale orchard producing cider apples for vertically integrated operation	Renewing 100+ year old apple orchard with high-density cider orchard	Small-scale organic production focused on the health of the environment	Large scale, vertically integrated orchard just beginning harvests of specialized cider apples	Very large commercial orchard just beginning trials of cider specific fruit
Farm structure	High costs with high returns	Low costs with low returns	Average costs and returns	Low yields with high returns	Low costs and low returns	Average costs and returns
Distance between trees and rows (feet)	4 x 16	4 x 12	4 x 12	4 x 20	8 x 18	3.25 x 12
Tree density (trees per acre)	680	908	908	436	308	1,117
Trellis system ($ per acre)	$3,681	$1,948	$6,318	3,833	No	$4,380
Irrigation system ($ per acre)	$365	No	No	No	No	$863
Harvest costs ($ per acre)	$2,000	$1,050	$600	$817	$719	Included below
Other labor costs ($ per acre)	$3,000	$457	$1,050	$631	$388	$4,837
Pesticide costs ($ per acre)	$1,000	$535	$782	$400	$750	$893
Establishment costs ($ per acre)	$16,953	$9,688	$19,902	$12,087	$5,504	$24,104
Annual yields at full production (pounds per acre)	52,000	28,000	35,700	16,600	40,000*	32,000*
Returns ($ per pound)	$0.71	$0.34	$0.54	$0.60	$0.15*	$0.35*
Breakeven year	8	7	9	9	19*	N/A*
Net present value after 25 years ($ per acre)	$89,593	$23,104	$38,196	$18,954	$4,245*	-$33,853*

*** Forecast data based on non-cider specific production.**

United Kingdom (UK), mature cider apple orchards of 'Dabinett' and 'Michelin' often yield 50,000 pounds per acre (personal communication, Neil Macdonald, Orchard Groundcare, Somerset, UK, 19 October 2017). As New York apple producers gain more experience growing cider apple cultivars, they will be able to better gauge expected yields.

Establishment costs ranged from $5,500 (ORCHARD5) to $24,100 per acre (ORCHARD6), with tree density and orchard design, such as the need for trellising and irrigation, being the main drivers for this 4.4-fold difference (Table 1). At 1,117 trees per acre, the ORCHARD6 operation had the greatest tree density, followed by ORCHARD2 and ORCHARD3 at 908 trees per acre. The ORCHARD5 operation planted 70% fewer trees per acre than ORCHARD6, and used semi-dwarf rootstocks and no trellis system. In fact, the ORCHARD5 operation was the only operation not to use a trellis system. The ORCHARD3 operation trellis cost three times as much as the ORCHARD2 trellis, even though they planted trees at the same density.

Economic case studies conducted in Washington State were based on high-density orchards planted at 5 feet between trees and 12 feet between rows for a planting density of 726 trees per acre (Galinato et al. 2014). The Virginia case study used by Farris et al. (2013) assumed a planting density of 5 feet between trees and 15 feet between rows for a density of 581 trees per acre. Clearly, there is a lack of uniformity in how cider apple orchards are being established in New York and elsewhere in the U.S., as well as the costs that are incurred for these new plantings. This is in contrast to more mature cider apple production regions, such as the UK, where "bush" cider apple orchards are typically planted at 6 to 8 feet between trees and 16 to 18 feet between rows for a tree density between 302 to 454 trees per acre (Umpelby and Copas 2002). These "bush" orchards typically do not use trellising or irrigation.

The main annual operating costs per acre included hand harvesting labor ($600 to $2,000), other labor ($400 to $3,000), and pesticide applications ($400 to $1,000) (Table 1). The mean values of these costs are similar to those reported for growing culinary apples in New York by Peck et al. (2010). The ORCHARD6 owners were unable to split out their harvest labor costs from their other labor costs, but their total annual labor costs per acre ($4,837) were similar to ORCHARD1 ($5,000). These two operations had considerably greater labor costs than the other four operations, which had an average of $1,430 per acre. Reducing harvest labor costs through the use of mechanical harvesting, as well as mechanizing other operations, such as pruning, should make cider apple orchards more economically profitable, so long as the equipment is affordably priced, or perhaps shared among producers. Currently, there is almost no mechanical harvesting of cider apples in the U.S.

Long-term pricing for cider apples remains largely unknown for the New York and, for that matter, the U.S. cider apple marketplace. The case study cider apple orchard operators provided prices ranging from $0.15 to $0.71 per pound (Table 1). Recent surveys suggest current mean prices per pound to be $0.28 (range $0.11 and $0.95) in New York (Pashow 2018), $0.32 in the Upper Midwest (Raboin 2017), $0.35 in Washington (Galinato et al. 2014), $0.36 in Virginia (Farris et al. 2013), and $0.45 in Vermont (Becot et al. 2016). Based on these surveys, the overall mean price for cider apples in the U.S. is $0.35 per pound. However, it should be noted that all of these surveys had a relatively low sample size.

In the UK, the majority of cider apples are sold via contracts with larger scale cider producers and receive prices between $0.06 to $0.08 per pound (personal communication, Neil Macdonald, Orchard Groundcare, Somerset, UK, 19 October 2017). At these prices, many cider apple growers in the UK are receiving returns that are at or even below their cost of production (personal communication, Rob Collins, RE Collins HS Ltd., Herefordshire, UK, 18 October 2017). The long-term sustainability of the U.S. cider market will likely require that cider producers pay prices that are considerably higher than those in the UK, in essence to outbid the opportunity that commercial apple growers have to plant more profitable apple cultivars and/or crops.

The ORCHARD5 operation had the lowest establishment and annual operating costs among case studies. The ORCHARD5 owners had no long-term information on how to set a market price for cider apples, and thus used prices reflective of apples that they currently sell on the wholesale processing market ($0.15 per pound). While this low price seems pessimistic, it is approximately twice as much as cider apples currently sell for in the UK. Conversely, the seemingly high prices that the ORCHARD1 producer expected to receive were above those that are typically received for high-value culinary apples, such as Honeycrisp. This grower was among the first to sell cider apples in New York and has been able to set prices that reflect a high demand and minimal supply.

Table 2. Sensitivity analyses of net annual income before taxes for the ORCHARD1 case study. The center value (highlighted) is the calculated mean value based upon data collected from the producer. The other values represent ± 10, 20, and 30 percent of the calculated values for both the yields (horizontally) and returns (vertically).

Median Return per lb	Median Yield (bushels/acre)						
	875	1,000	1,125	1,250	1,375	1,500	1,625
$0.50	$ 9,790	$ 12,415	$ 15,040	$ 17,665	$ 20,290	$ 22,915	$ 25,540
$0.57	$ 12,415	$ 15,415	$ 18,415	$ 21,415	$ 24,415	$ 27,415	$ 30,415
$0.64	$ 15,040	$ 18,415	$ 21,790	$ 25,165	$ 28,540	$ 31,915	$ 35,290
$0.71	$ 17,665	$ 21,415	$ 25,165	$ 28,915	$ 32,665	$ 36,415	$ 40,165
$0.79	$ 20,290	$ 24,415	$ 28,540	$ 32,665	$ 36,790	$ 40,915	$ 45,040
$0.86	$ 22,915	$ 27,415	$ 31,915	$ 36,415	$ 40,915	$ 45,415	$ 49,915
$0.93	$ 25,540	$ 30,415	$ 35,290	$ 40,165	$ 45,040	$ 49,915	$ 54,790

Table 3. Sensitivity analyses of net annual income before taxes for the ORCHARD2 case study. The center value (highlighted) is the calculated mean value based upon data collected from the producer. The other values represent ± 10, 20, and 30 percent of the calculated values for both the yields (horizontally) and returns (vertically).

Median Return per lb	Median Yield (bushels/acre)						
	490	560	630	700	770	840	910
$0.24	$ 2,067	$ 2,766	$ 3,464	$ 4,162	$ 4,860	$ 5,559	$ 6,257
$0.27	$ 2,766	$ 3,564	$ 4,362	$ 5,160	$ 5,958	$ 6,756	$ 7,554
$0.31	$ 3,464	$ 4,362	$ 5,260	$ 6,157	$ 7,055	$ 7,953	$ 8,850
$0.34	$ 4,162	$ 5,160	$ 6,157	$ 7,155	$ 8,152	$ 9,150	$ 10,147
$0.37	$ 4,860	$ 5,958	$ 7,055	$ 8,152	$ 9,249	$ 10,347	$ 11,444
$0.41	$ 5,559	$ 6,756	$ 7,953	$ 9,150	$ 10,347	$ 11,544	$ 12,741
$0.44	$ 6,257	$ 7,554	$ 8,850	$ 10,147	$ 11,444	$ 12,741	$ 14,038

Table 4. Sensitivity analyses of net annual income before taxes for the ORCHARD3 case study. The center value (highlighted) is the calculated mean value based upon data collected from the producer. The other values represent ± 10, 20, and 30 percent of the calculated values for both the yields (horizontally) and returns (vertically).

Median Return per lb	Median Yield (bushels/acre)						
	595	680	765	850	935	1,020	1,105
$0.38	$ 3,941	$ 5,280	$ 6,618	$ 7,957	$ 9,296	$ 10,635	$ 11,973
$0.43	$ 5,280	$ 6,810	$ 8,340	$ 9,870	$ 11,400	$ 12,930	$ 14,460
$0.48	$ 6,618	$ 8,340	$ 10,061	$ 11,782	$ 13,503	$ 15,225	$ 16,946
$0.54	$ 7,957	$ 9,870	$ 11,782	$ 13,695	$ 15,607	$ 17,520	$ 19,432
$0.59	$ 9,296	$ 11,400	$ 13,503	$ 15,607	$ 17,711	$ 19,815	$ 21,918
$0.64	$ 10,635	$ 12,930	$ 15,225	$ 17,520	$ 19,815	$ 22,110	$ 24,405
$0.70	$ 11,973	$ 14,460	$ 16,946	$ 19,432	$ 21,918	$ 24,405	$ 26,891

In separate analyses, enterprise budgets for the six operations were calculated using a set price of $0.35 per pound, instead of the prices given by the orchard operators (Figure 2). In this analysis, the ORCHARD2 and ORCHARD5 operations became the most profitable, while the ORCHARD1 operation went from being the most profitable, using their price of $0.71 per pound (twice the national average), to not achieving profitability. The unprofitability for the ORCHARD6 operation remained the same because they used the national average price in their budget assumptions.

Sensitivity analyses were constructed for each operation to account for 10, 20, and 30 percent decrease or increase in the calculated values for both the yields and returns (Tables 2-7). Even with a 30% decrease in both yields and returns, all but the ORCHARD6 operation remained profitable. This was despite the fact that the orchards were located in different climatic regions and had different management approaches for pest and disease control. However, the ORCHARD5 operation would only be $90 above the breakeven point each year. On the other end of the spectrum, with the same 30% reductions, the ORCHARD1 operation would still be profiting by $26,891 per year. The sensitivity analyses found that the operations had considerable overlap in their annual profitability. This includes the ORCHARD6 operation, which with a 30% increase in yield (to 1,008 bushels per acre) and maintaining a $0.35 per pound price, would have a $5,417 annual profit.

The sensitivity analyses show that most cider apple orchards can be profitable in New York, even with much lower yields and/or prices than the operators of our case studies have provided. Although six case studies is a small a sample size to make overarching statements about a mean cost of production or expected returns for cider apples in New York State, the data should give potential cider apple growers an estimation for the range of profitability that is possible. Additional case studies are under way, which will add more confidence in the mean profit potential. Growers can develop enterprise budgets for their own operation by using the free Excel® templates that are available online at: https://pubs.ext.vt.edu/AREC/AREC-46/AREC-46.html (Farris et al. 2013).

The ORCHARD4 operation utilized organic practices, and while they estimated the lowest yields among the six case studies, they also had the lowest pesticide costs (Table 1). Other studies, such as Peck et al. (2010), have shown that organic pest control programs for culinary apples can be more expensive than conventional pest control programs. The ORCHARD4 operation uses a very low input system and is willing to have a significant percentage of their fruit be cosmetically damaged, knowing that the fruit is destined to be processed into cider. This brings up the important point that the economic case studies presented in this paper only account for a monetary valuation of the enterprise. Future studies should expand this work to include environmental and social metrics to gain a better understanding of the overall sustainability of these operations.

The U.S. industry is emerging in many regions where growers produce culinary apples using high-density systems. Five of the six case studies are using methods that are more similar to culinary apple orchards (such as higher tree densities) than processing orchards. Our analyses suggest that using high-density

Table 5. Sensitivity analyses of net annual income before taxes for the ORCHARD4 case study. The center value (highlighted) is the calculated mean value based upon data collected from the producer. The other values represent ± 10, 20, and 30 percent of the calculated values for both the yields (horizontally) and returns (vertically).

Median Return per lb	Median Yield (bushels/acre) 277	317	356	396	436	475	515
$0.42	$ 1,882	$ 2,575	$ 3,268	$ 3,961	$ 4,654	$ 5,347	$ 6,040
$0.48	$ 2,575	$ 3,367	$ 4,159	$ 4,951	$ 5,743	$ 6,535	$ 7,327
$0.54	$ 3,268	$ 4,159	$ 5,050	$ 5,941	$ 6,832	$ 7,723	$ 8,614
$0.60	$ 3,961	$ 4,951	$ 5,941	$ 6,931	$ 7,921	$ 8,911	$ 9,901
$0.65	$ 4,654	$ 5,743	$ 6,832	$ 7,921	$ 9,010	$ 10,099	$ 11,188
$0.71	$ 5,347	$ 6,535	$ 7,723	$ 8,911	$ 10,099	$ 11,287	$ 12,475
$0.77	$ 6,040	$ 7,327	$ 8,614	$ 9,901	$ 11,188	$ 12,475	$ 13,762

Table 6. Sensitivity analyses of net annual income before taxes for the ORCHARD5 case study. The center value (highlighted) is the calculated mean value based upon data collected from the producer. The other values represent ± 10, 20, and 30 percent of the calculated values for both the yields (horizontally) and returns (vertically).

Median Return per lb	Median Yield (bushels/acre) 543	620	698	775	853	930	1,008
$0.11	$ 90	$ 432	$ 774	$ 1,116	$ 1,457	$ 1,799	$ 2,141
$0.12	$ 432	$ 823	$ 1,213	$ 1,604	$ 1,994	$ 2,385	$ 2,776
$0.14	$ 774	$ 1,213	$ 1,653	$ 2,092	$ 2,532	$ 2,971	$ 3,410
$0.15	$ 1,116	$ 1,604	$ 2,092	$ 2,580	$ 3,069	$ 3,557	$ 4,045
$0.17	$ 1,457	$ 1,994	$ 2,532	$ 3,069	$ 3,606	$ 4,143	$ 4,680
$0.18	$ 1,799	$ 2,385	$ 2,971	$ 3,557	$ 4,143	$ 4,729	$ 5,315
$0.20	$ 2,141	$ 2,776	$ 3,410	$ 4,045	$ 4,680	$ 5,315	$ 5,949

Table 7. Sensitivity analyses of net annual income before taxes for the ORCHARD6 case study. The center value (highlighted) is the calculated mean value based upon data collected from the producer. The other values represent ± 10, 20, and 30 percent of the calculated values for both the yields (horizontally) and returns (vertically).

Median Return per lb	Median Yield (bushels/acre) 543	620	698	775	853	930	1,008
$0.25	$ (3,921)	$ (3,114)	$ (2,307)	$ (1,500)	$ (693)	$ 114	$ 921
$0.28	$ (3,114)	$ (2,191)	$ (1,269)	$ (347)	$ 575	$ 1,498	$ 2,420
$0.32	$ (2,307)	$ (1,269)	$ (232)	$ 806	$ 1,844	$ 2,881	$ 3,919
$0.35	$ (1,500)	$ (347)	$ 806	$ 1,959	$ 3,112	$ 4,264	$ 5,417
$0.39	$ (693)	$ 575	$ 1,844	$ 3,112	$ 4,380	$ 5,648	$ 6,916
$0.43	$ 114	$ 1,498	$ 2,881	$ 4,264	$ 5,648	$ 7,031	$ 8,415
$0.46	$ 921	$ 2,420	$ 3,919	$ 5,417	$ 6,916	$ 8,415	$ 9,913

plantings will be economically sustainable, so long as the prices for cider apples resemble those of culinary apples more so than processing apples. Continued high demand with minimal supply for cider apples is likely to continue for some time. Our recent survey data suggests that there are only around 200 acres of cider apples planting in New York (Pashow 2018).

Additionally, high-density orchards are also more sensitive to price fluctuations and crop failures; thus, they carry a greater risk to the grower (Robinson et al. 2013). So while growing cider apples using a high-density system may reward growers who are experienced with these techniques and already have the existing infrastructure, it may also cause many start-up operations to be unprofitable, particularly if they make mistakes in their orchard design, cultivar selection, or annual management practices. Vertically integrated operations that are growing cider apples, as well as making cider, may also have an advantage in that they only need to cover the cost of producing cider apples, as they will add value to the raw materials.

Understanding the horticultural considerations needed for producing cider apples in the U.S. is the focus of several research teams. It is still unclear what the most productive and profitable cider apple cultivars will be in the U.S. In addition to replicated research trials being conducted by university scientists, many growers are experimenting with a wide range of different genotypes. For the case studies discussed in this paper, we did not segregate among different cultivars because the owners did not have enough experience to provide sufficiently detailed information about this component.

Conclusions

Hard cider production contributes to the regional economy by creating new jobs and increasing tourism. A recent Cornell study found that New York hard cider producers contributed $44M in direct economic impacts (personal communication, Todd Schmit, Cornell University, 1 November 2017). The case studies presented here encompass a wide variety of production systems and marketing strategies, with the hope of providing other growers with statistics on orchards more similar to their own than a set of averaged data. These case studies show that there is also a clear opportunity for New York's apple growers to profitably increase the production of specialized cider apples. Lastly, in order to remain viable in an increasingly competitive marketplace, New York's hard cider industry needs sound research-based information to facilitate the increase in hard cider apple production.

Acknowledgments

We thank the cider apple growers who generously shared their time, production data, and financial records. Jarrad Farris and Dr. Gordon Groover provided technical assistance with the enterprise budgets. Microsoft® Excel® spreadsheets for the enterprise budgets used in this paper are available at: https://pubs.ext.vt.edu/AREC/AREC-46/AREC-46.html. Additional information about hard cider production in New York is available at: hardcider.cals.cornell.edu. Angry Orchard Cider Company, LLC provided financial support for this project.

References

Becot, F. A., Bradshaw, T. L., and Conner, D. S. 2016. Apple market expansion through value-added hard cider production: current production and prospects in Vermont. HortTechnology 26(2): 220–229.

Brager, D. and Crompton, M. 2017. Cider trends in the U.S. and abroad. The Nielsen Company (US), LLC. [online] https://trello.com/b/HTzKVqSK/2017-cidercon-presentations. (Accessed 29 April 2018).

Brown, D. 2018. Cider maker survey: current USA cider makers survey – Updated January 2018. [online] https://www.cydermarket.com/cider-maker-survey.html. (Accessed 29 April 2018).

Cazentre, D. 2014. Anheuser-Busch's new hard apple cider to be made exclusively at Baldwinsville brewery. [online] https://www.syracuse.com/drinks/index.ssf/2014/03/made_in_baldwinsville_anheuser.html. (Accessed 29 July 2018).

Farris, J. G., Peck, G. M., and Groover, G. E. 2013. Assessing the Economic Feasibility of Growing Specialized Apple Cultivars for Sale to Commercial Hard Cider Producers. VA Coop. Ext. Pub. AREC-46P, Blacksburg, VA. [online] https://pubs.ext.vt.edu/AREC/AREC-46/AREC-46.html. (Accessed 29 April 2018).

Galinato, S. P., Gallardo, R. K., and Miles, C. A. 2014. 2013 Cost Estimation of Establishing a Cider Apple Orchard in Western Washington. Washington State Univ. Ext. Fact Sheet FS141E, Pullman, WA.

Pashow, L. 2018. Hard cider supply chain analysis. Cornell Coop. Ext. – Harvest New York, Malone, NY.

Peck, G. M., Merwin, I. A., Brown, M. G., and Agnello, A. M. 2010. Integrated and organic fruit production systems for 'Liberty' apple in the Northeast USA: a systems-based evaluation. HortScience 45(7): 1038–1048.

Petrillo, N. 2016. Cider production in the US: IBISWorld Industry Report OD5335. IBISWorld: Melbourne, Australia.

Raboin, M. 2017. Hard cider in the North Central Region: industry survey findings, University of Wisconsin-Madison Center for Integrated Agricultural Systems, Madison, WI.

Robinson, T., Hoying, S., Miranda Sazo, M., DeMaree, A., and Dominguez, L. 2013. A vision for apple orchard systems of the future, NY Fruit Q. 21(3): 11–16.

TTB (U.S. Alcohol and Tobacco Tax and Trade Bureau). 2017. Statistical Report - Wine. ATTTB, Washington, D.C. Report Symbol TTB S 5120-12. Various years 2007–2017.

Umperly, R., and Copas, L. 2012. Growing Cider Apples. National Association of Cider Makers, London, UK.

USDA-NASS (U.S. Department of Agriculture-National Agricultural Statistics Service). 2017. Noncitrus Fruits and Nuts: 2016 Summary, Washington, DC.

Gregory Peck is an Assistant Professor in Cornell University's School of Integrative Plant Science. His research focuses on hard cider production, sustainable soil and groundcover management systems for apple orchards, and improving crop-load management in apple trees through the use of a pollen tube growth model. **Whitney Knickerbocker** has a Bachelor's Degree in Agribusiness Management from Cornell University. As a member of Gregory Peck's research team, he splits his time between investigating the economics of cider orchards and at his home field crop farm in upstate New York.